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Proven Ways to Reduce Operating Costs and Greenhouse Gas Emissions

Energy 2006
Chicago

Ian Spanswick
Product Manager – Industrial Systems

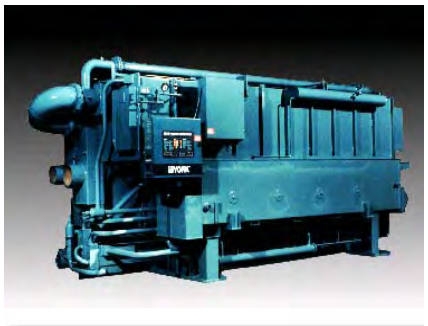
Excellence in Energy Efficiency

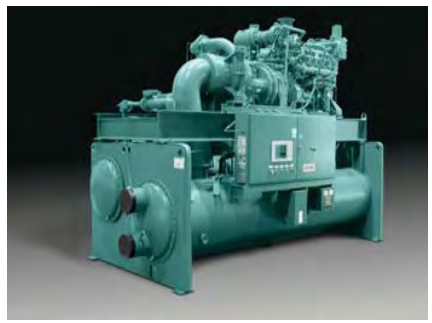
Agenda

Body Shop: Building Strategies

- Energy Supply Diversification
- Heat Pumps
- Onsite Thermal and Power Generation
- Comparison study - Economic and Environmental Benefits

Energy Supply Diversification





Hybrid Chiller Solution

Body Shop: Building Strategies

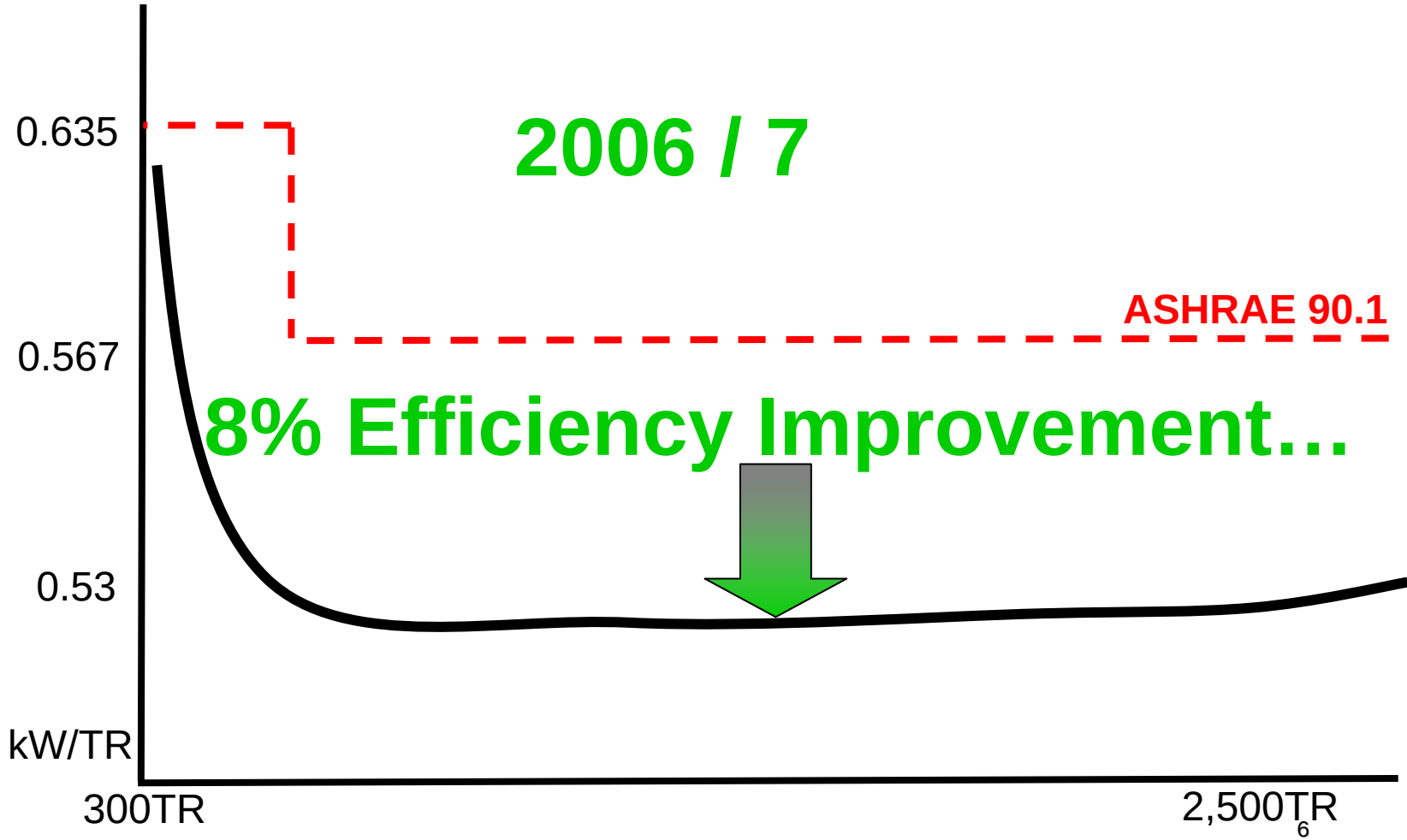
High Efficiency Electric Chillers

Body Shop: Building Strategies

250 to 3,000 TR / 880 to 10,000 kW

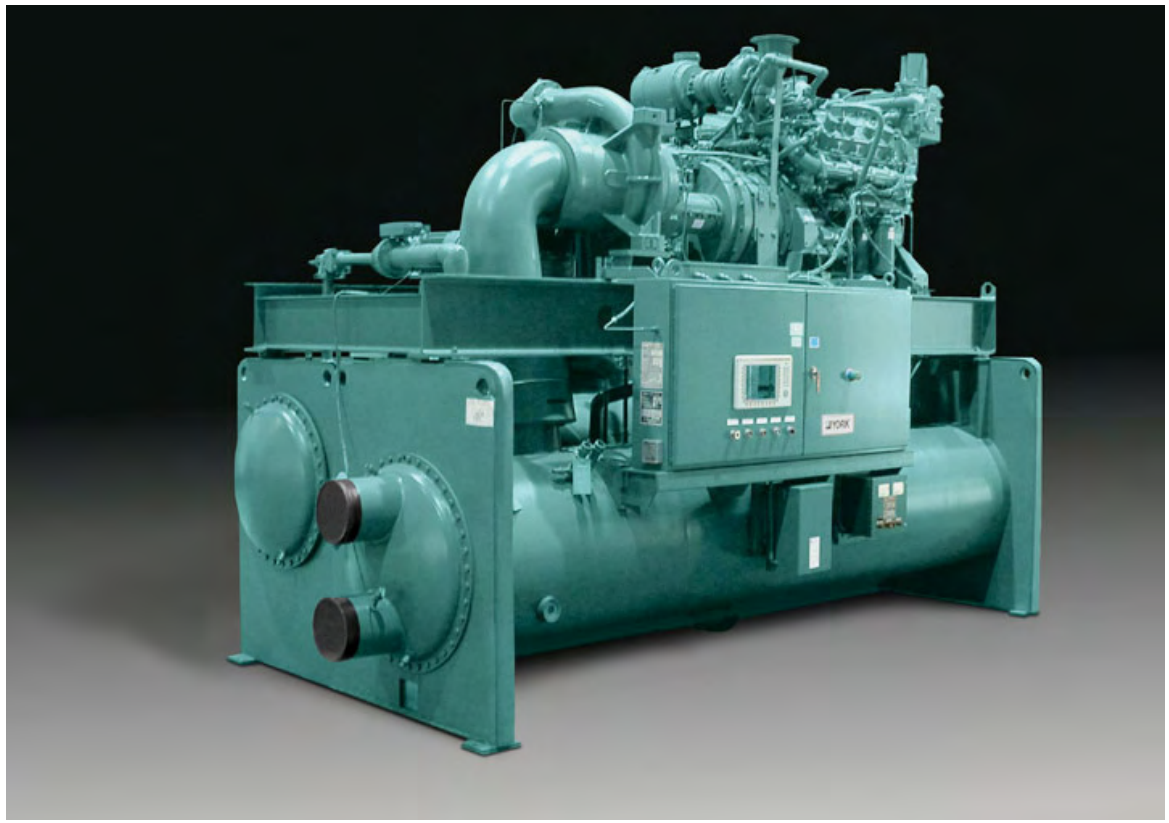
Improving Chiller Performance

Body Shop: Building Strategies



Gas Engine Drive Chillers

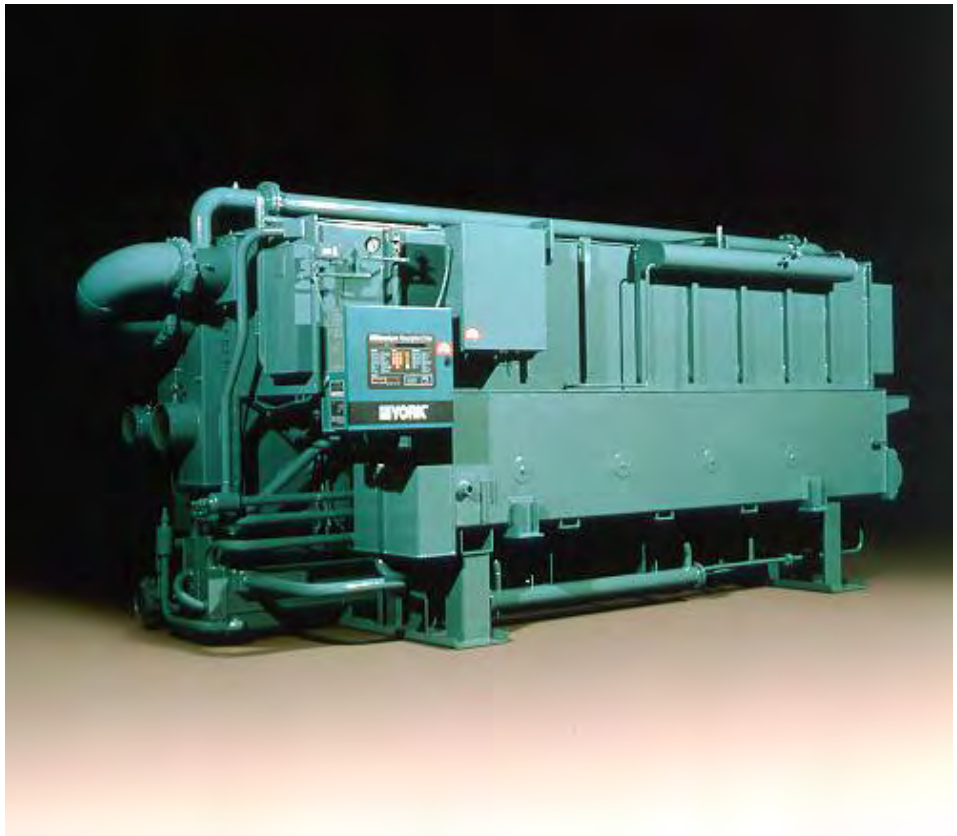
Body Shop: Building Strategies



400 to 1,900 TR, 1,400 to 6,700kW

Double Effect Absorption Chillers

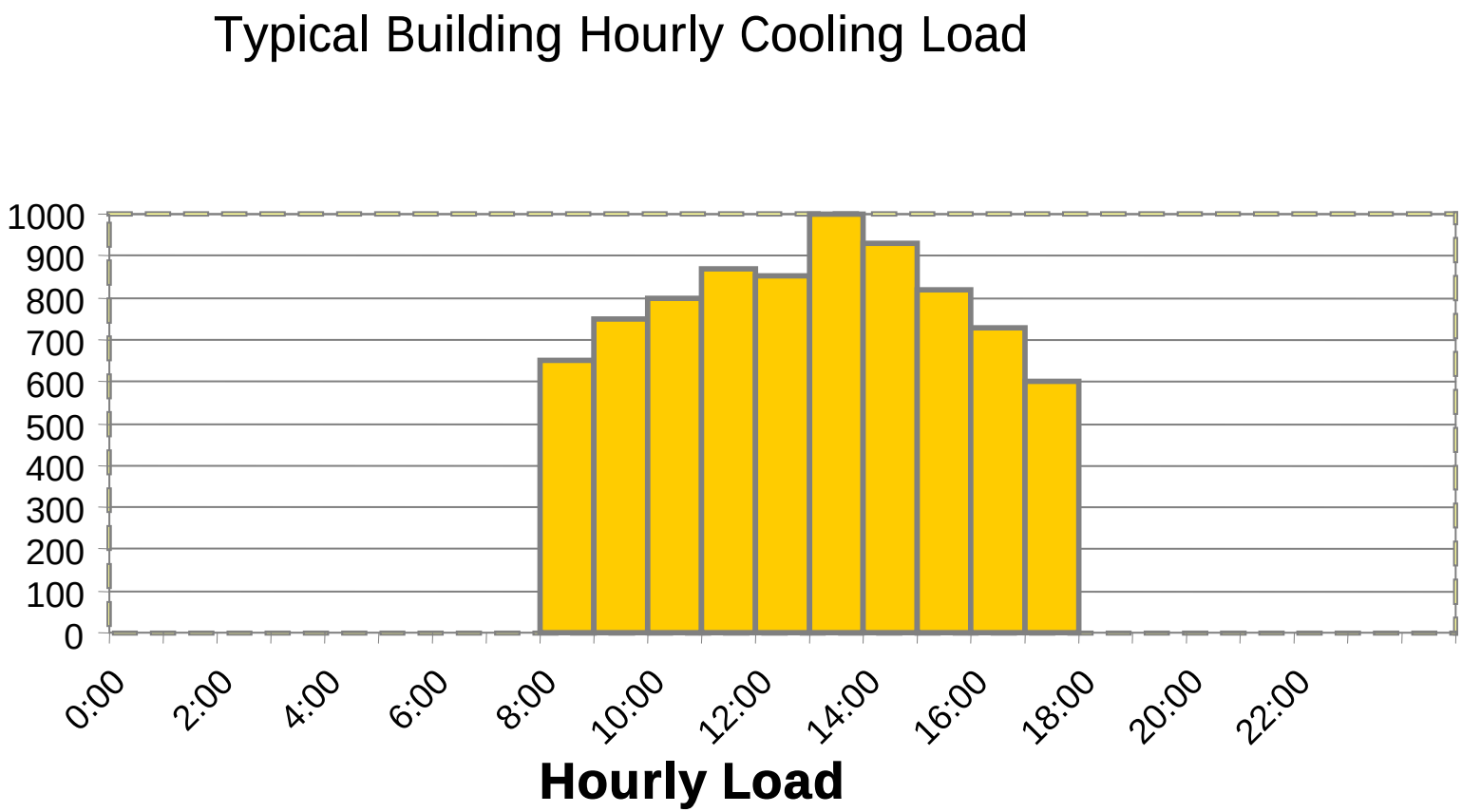
Body Shop:
Building
Strategies



200 to 700 TR, 700 to 2,400kW
Gas / Oil or MP Steam

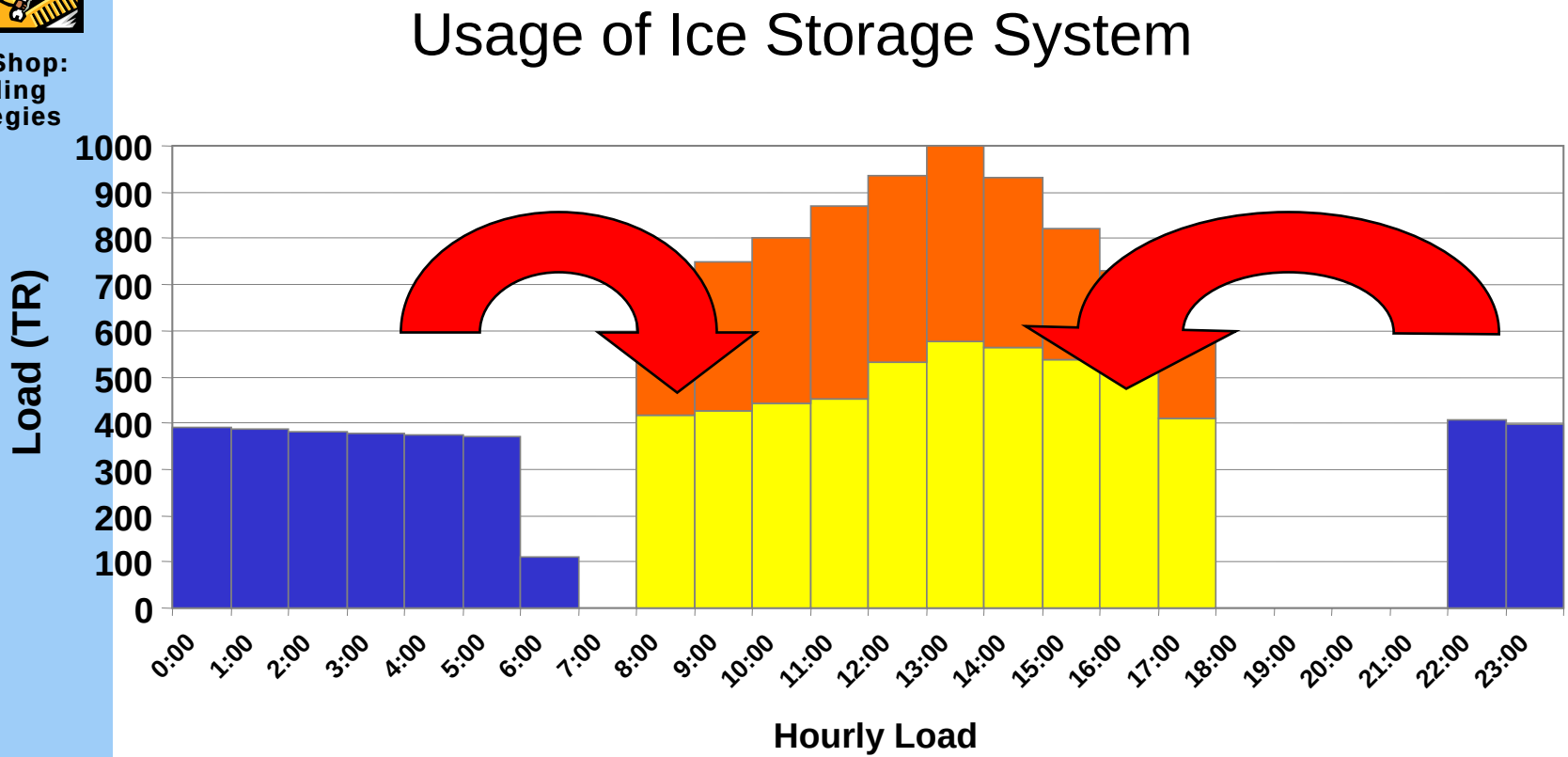
Thermal Storage Systems

Body Shop: Building Strategies



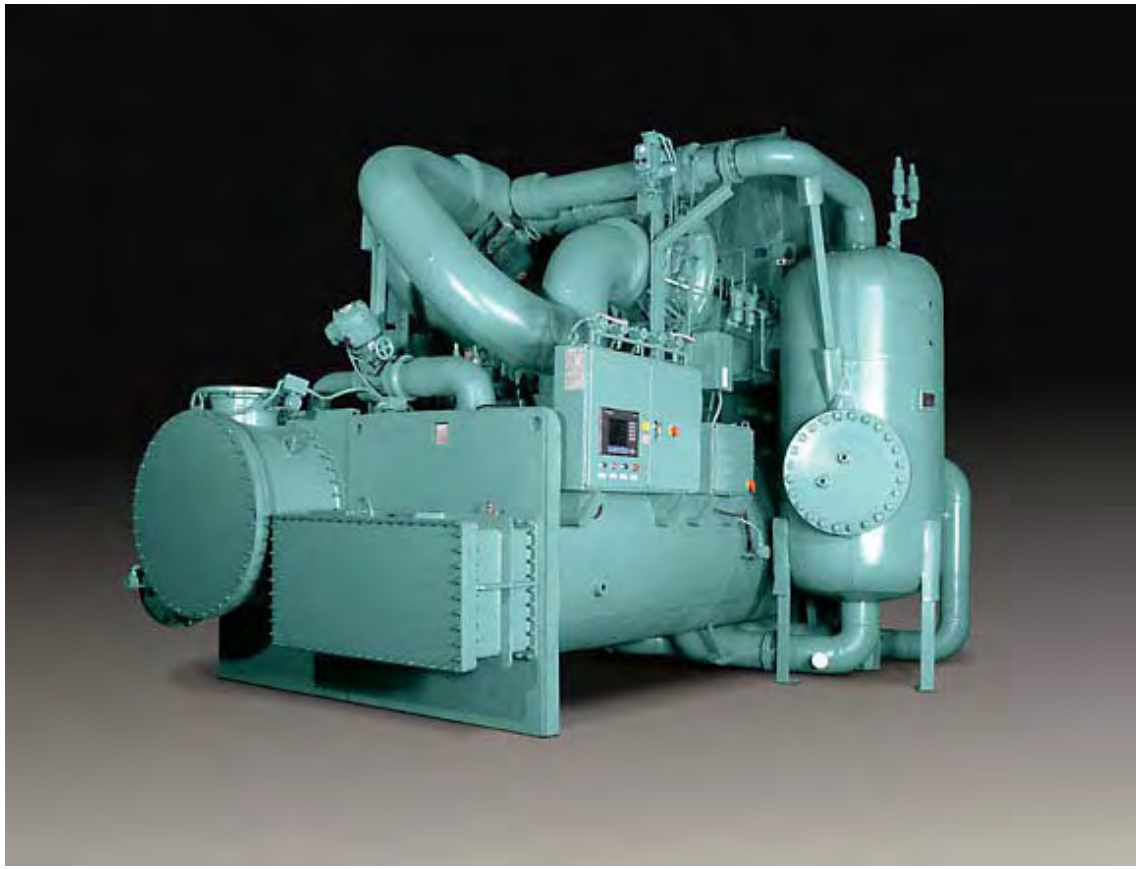
What is Ice Storage System?

Body Shop: Building Strategies



Compound Chillers

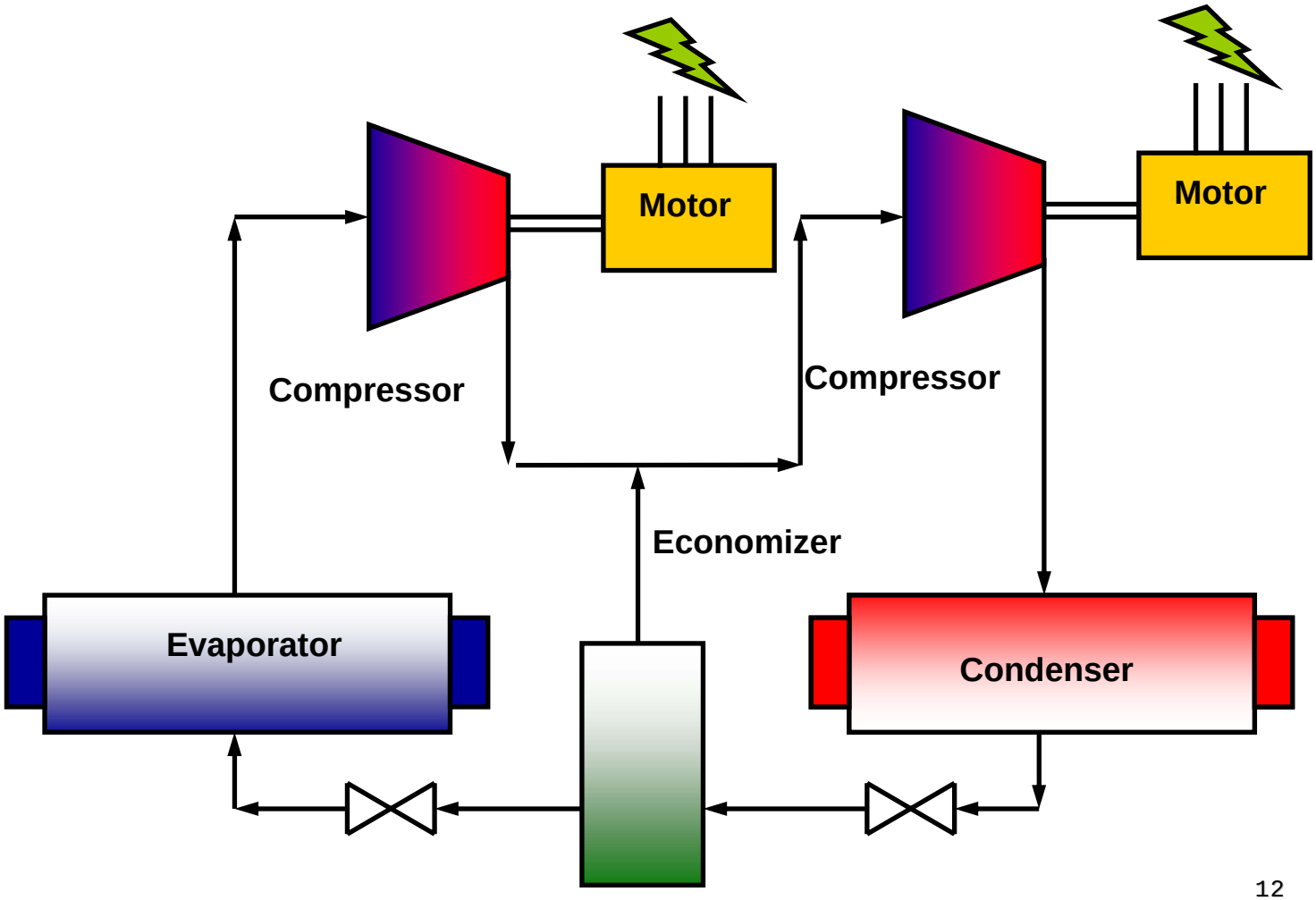
Body Shop: Building Strategies



500 to >2000 TR, 1,800 to >7,000kW

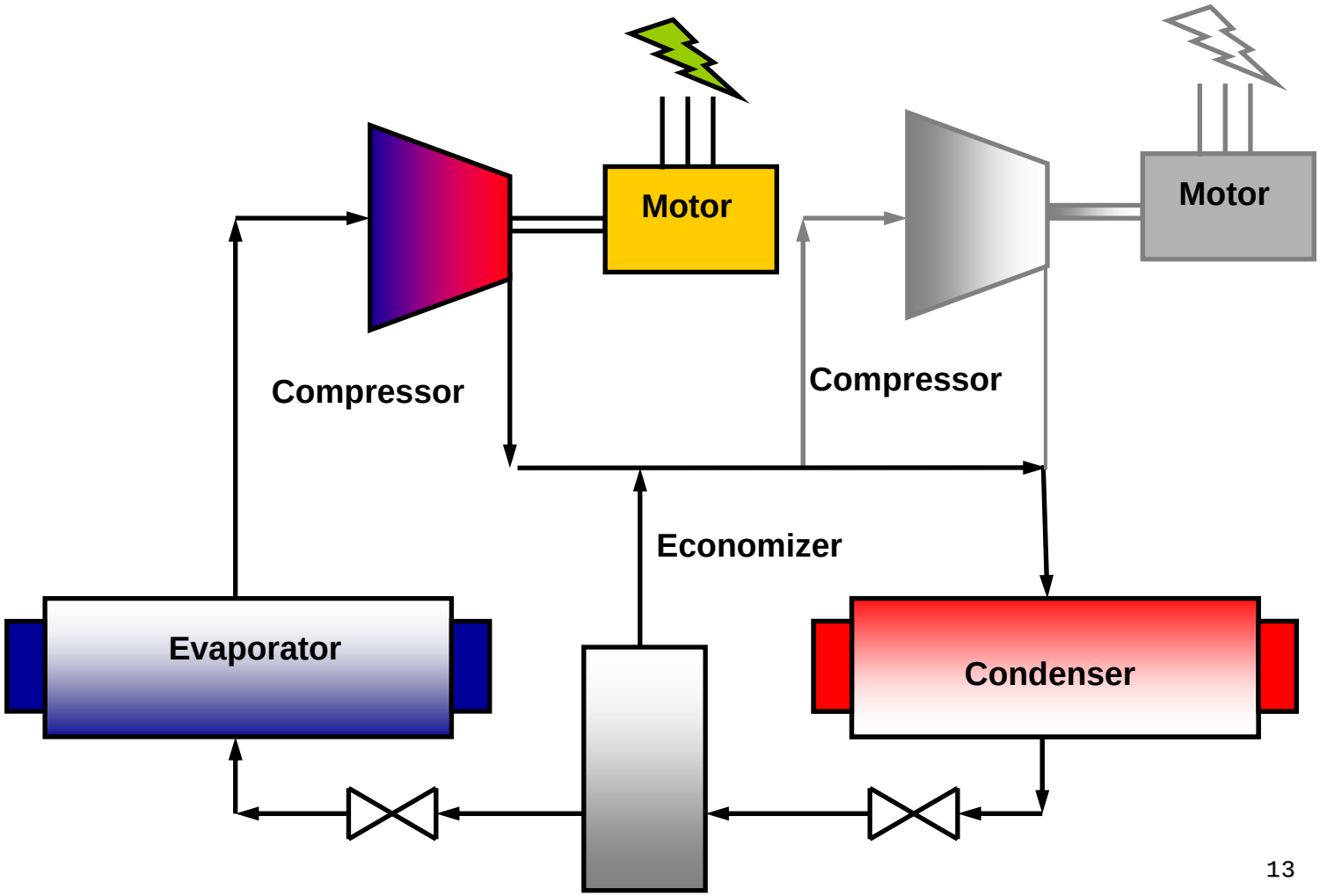
Thermal Storage Needs Flexibility

Body Shop: Building Strategies

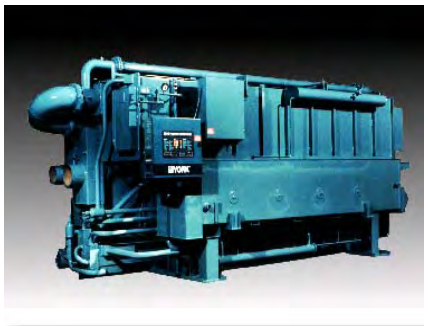


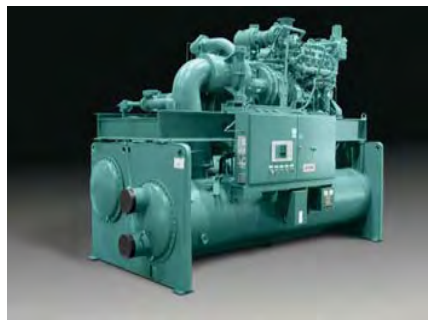
Thermal Storage – Daytime

Body Shop: Building Strategies



Heat Pumps

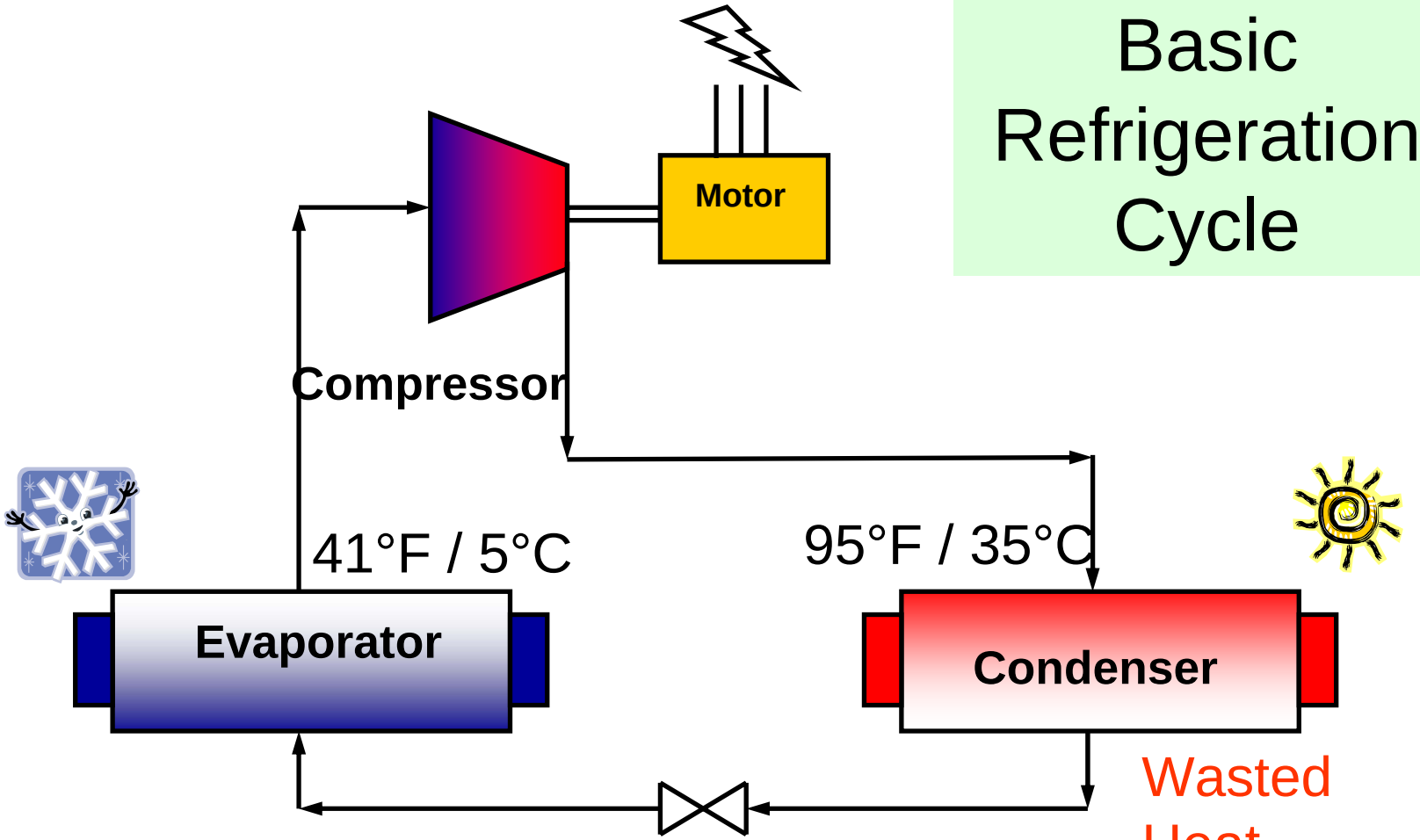




Heat Rejection

Body Shop: Building Strategies

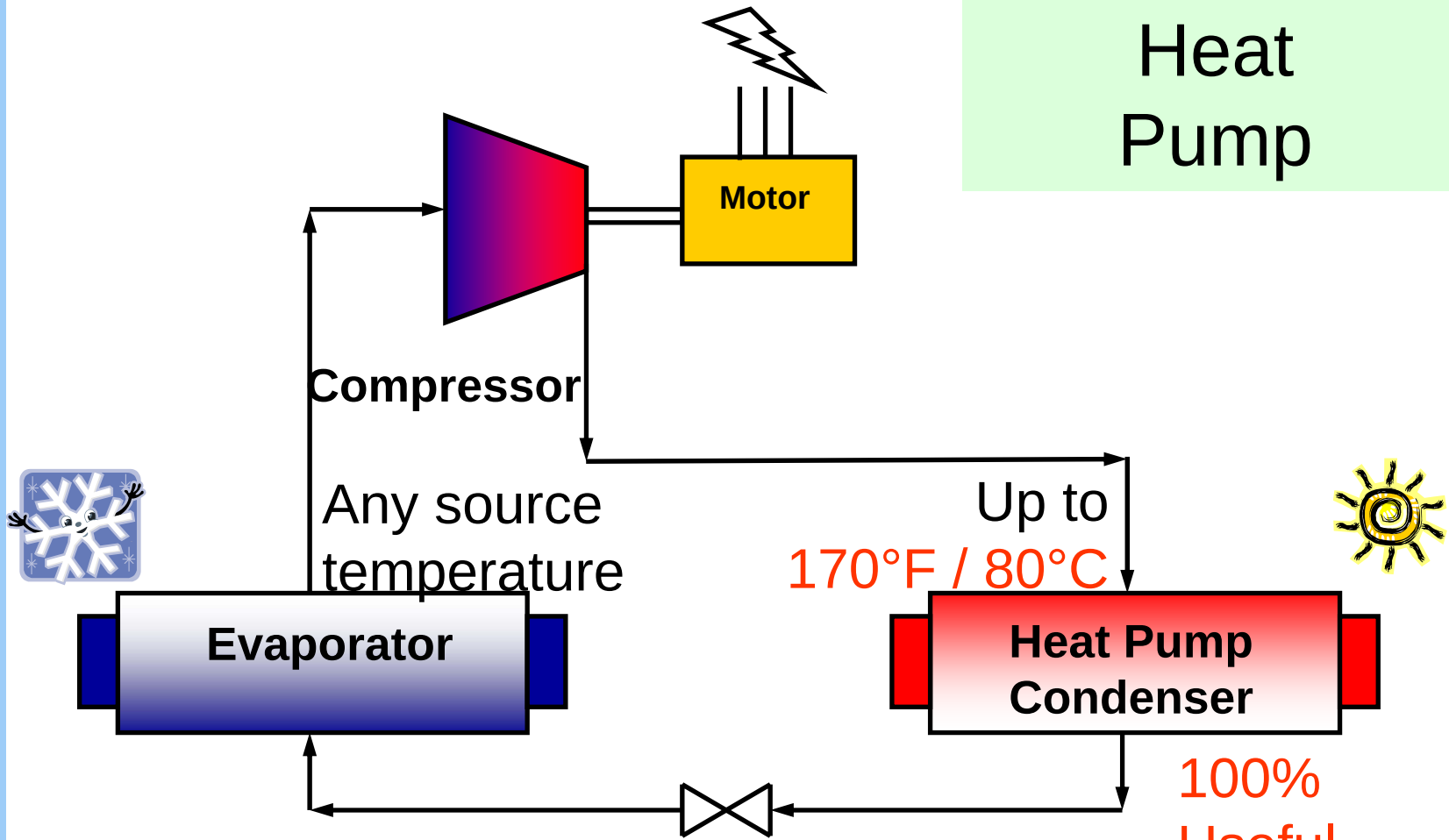
Basic Refrigeration Cycle



Heat Pump

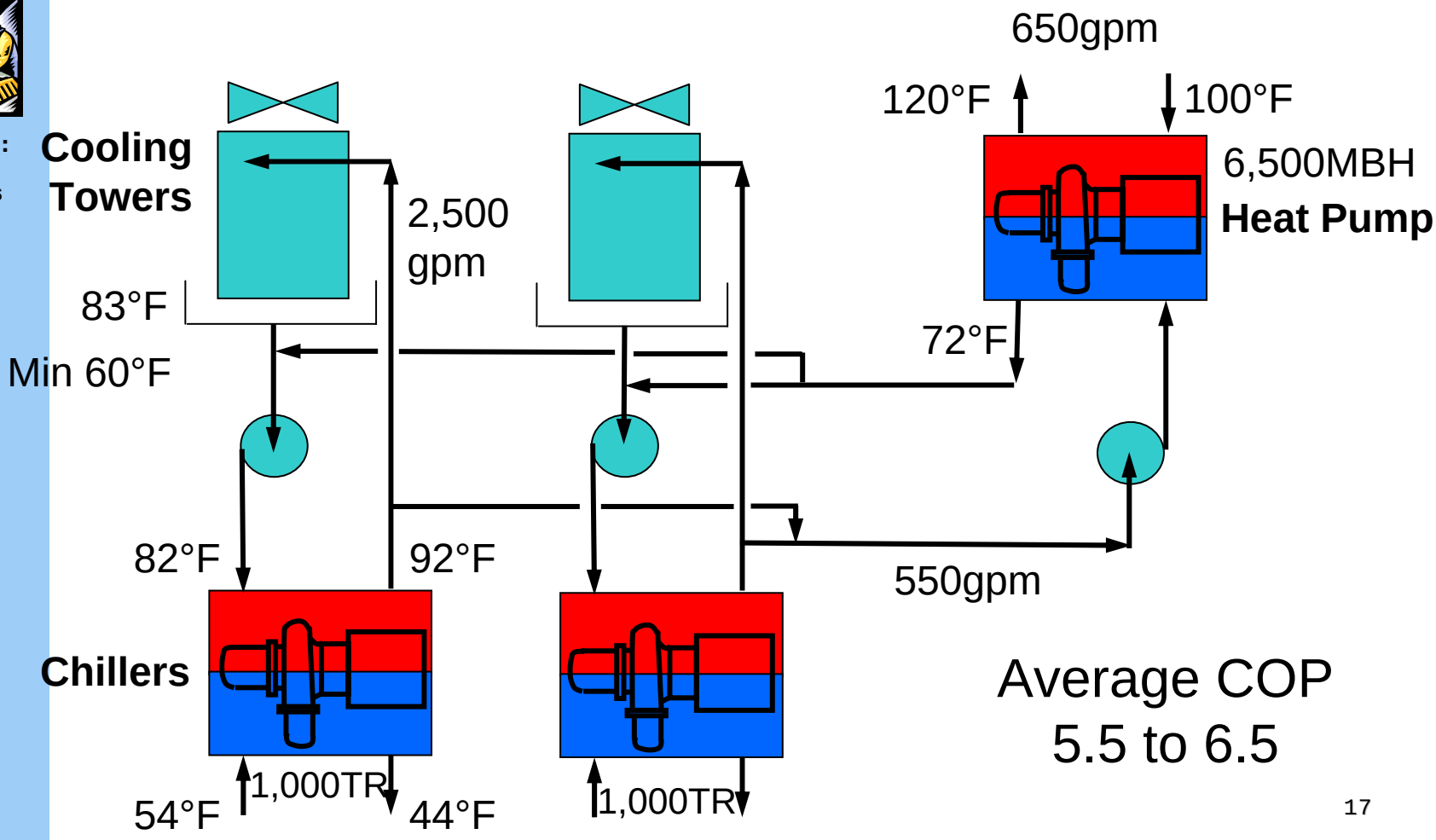
Body Shop: Building Strategies

Heat Pump



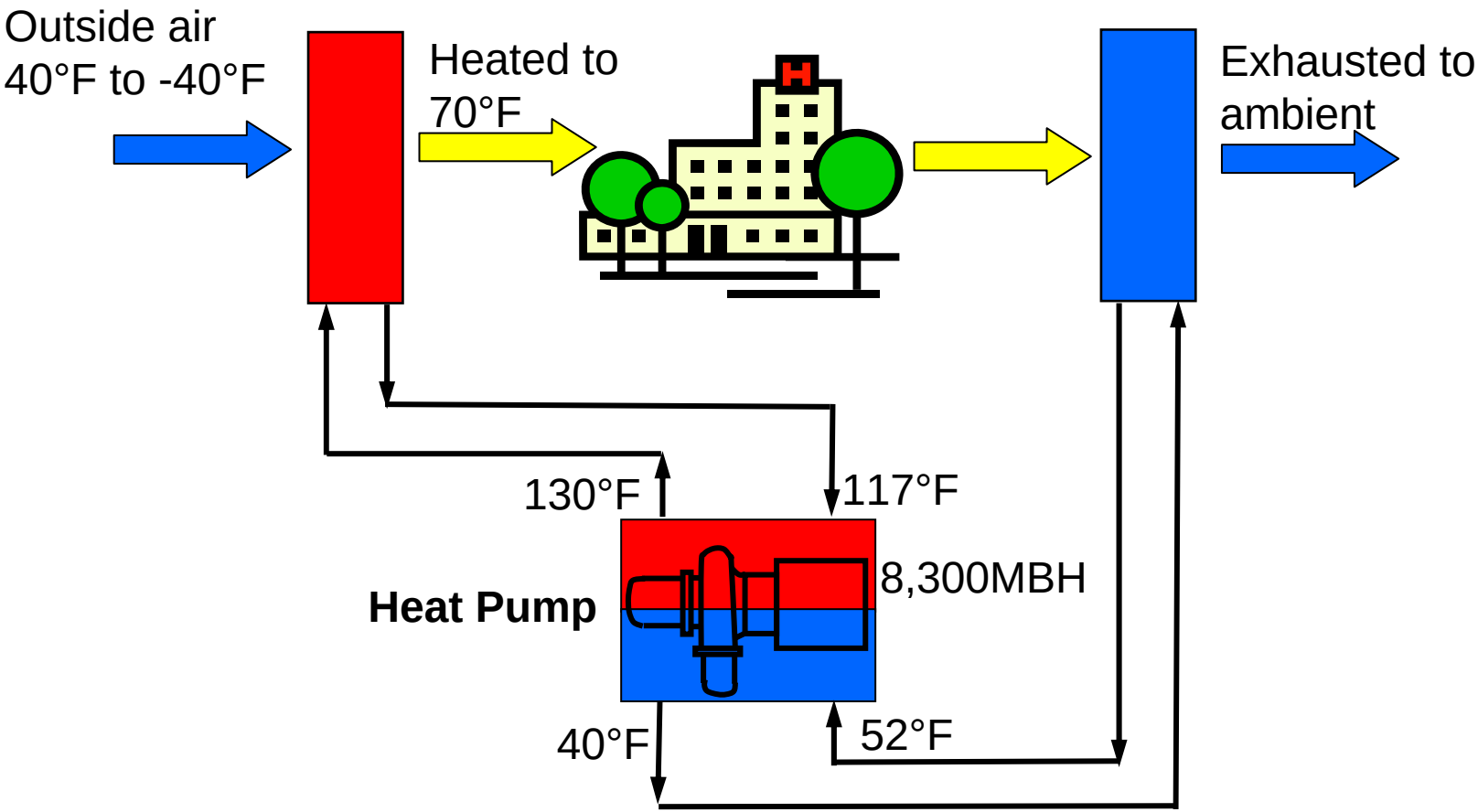
Heat from Cooling Towers

Body Shop: Building Strategies



Heat from Exhaust Air

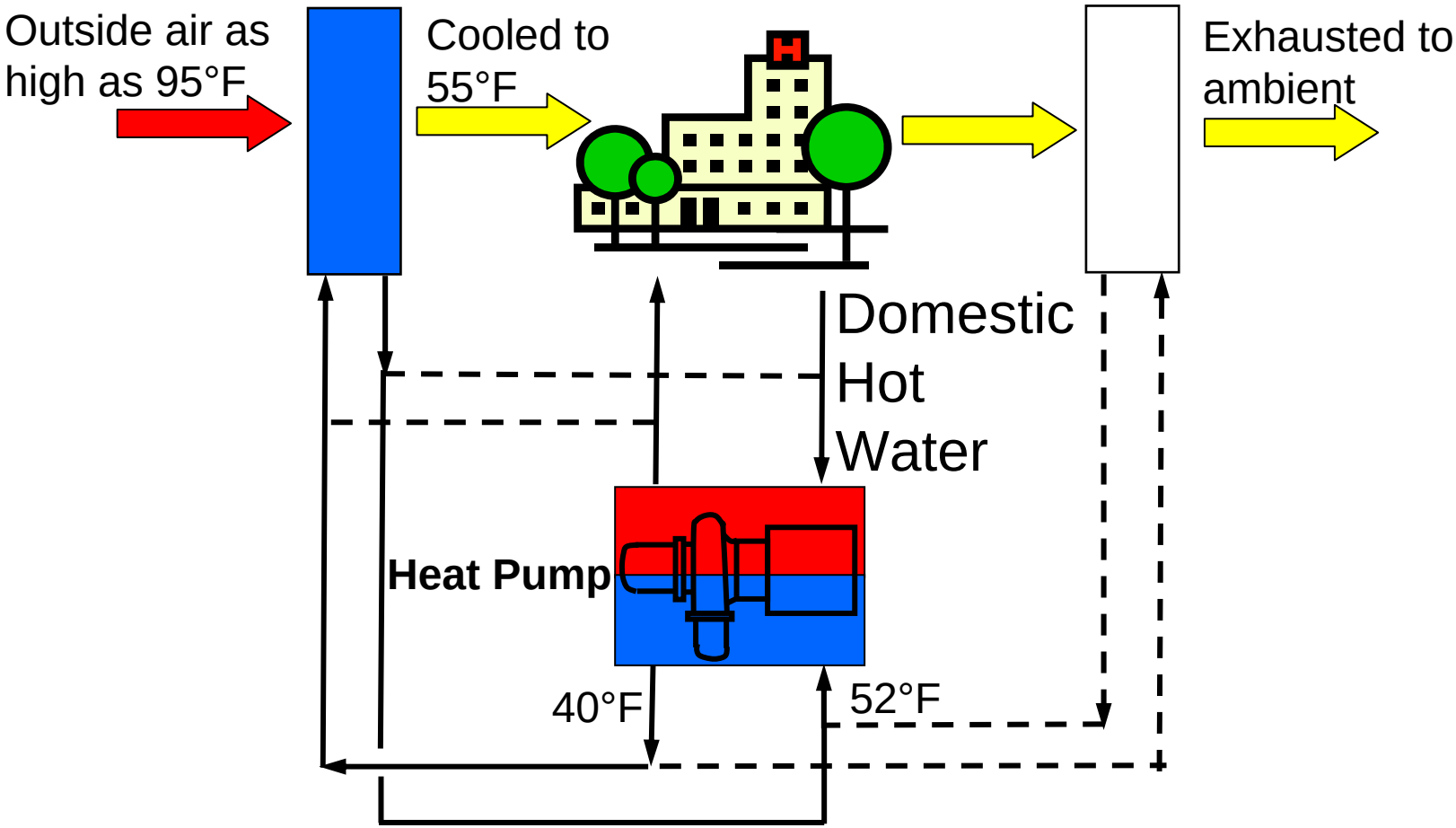
Body Shop: Building Strategies



Winter operation

Heat from Exhaust Air

Body Shop: Building Strategies



Summer operation

Cost to produce 100,000 BTU

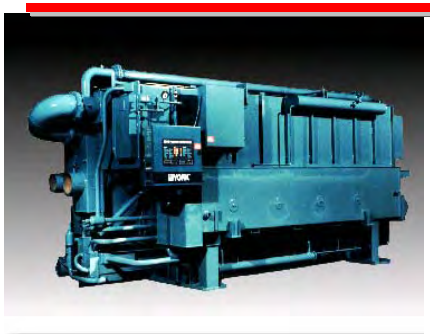
Body Shop: Building Strategies

- Natural Gas Water Heater
  - 100,000 Btu / 85% efficiency / 1000 Btu/ft^3 / $10.00/1000 ft^3 = **$1.18**
- Fuel Oil Water Heater
  - 100,000 Btu / 85% efficiency / 140,000 Btu/gal / $2.60/gal = **$2.19**
- Electric Water Heater
  - 100,000 Btu / 95% efficiency / 3412 BTU/hr/kW / $0.12/kW.hr = **$3.70**
- Heat Pump
  - 100,000 Btu / 600% efficiency / 3412 BTU/hr/kW / $0.12/kW.hr = **0.59**

COP = 6.0 (with cooling credit)

Body Shop: Building Strategies

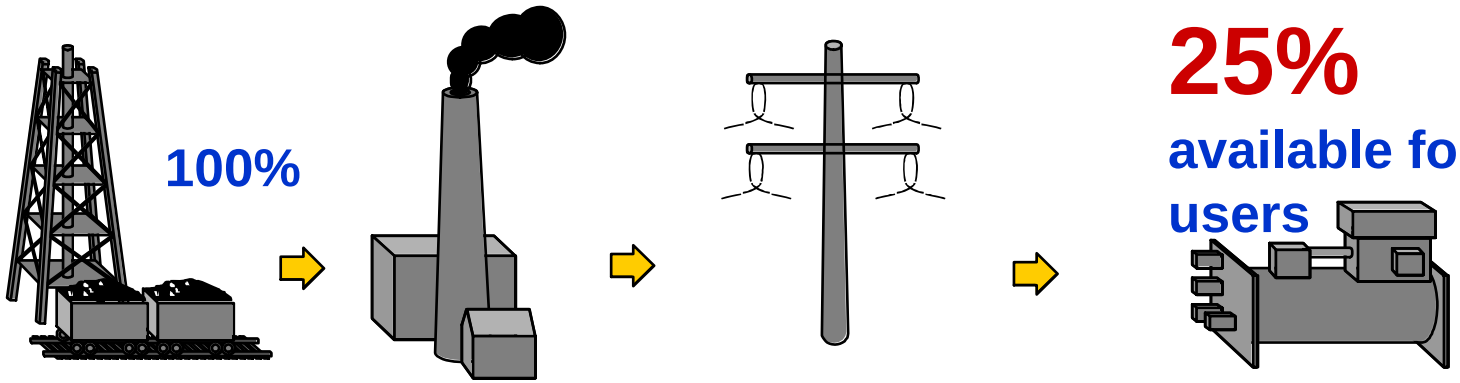
Onsite Thermal and Power Generation



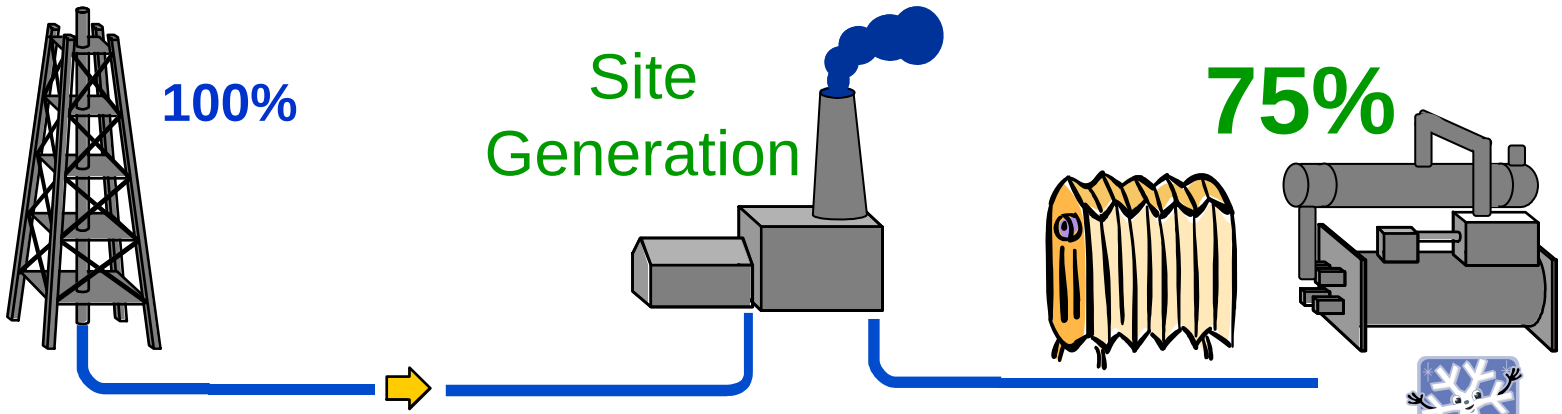
Energy Independence - CHP

Body Shop: Building Strategies

Traditional Power Generation



Distributed Generation, Heating & Cooling



Overall Reduction in CO_2 Emissions

Thermally Activated Technologies

Body Shop: Building Strategies

Distributed Generation Technologies

Thermally-Activated HVAC Technologies

800ºF

600ºF

360ºF

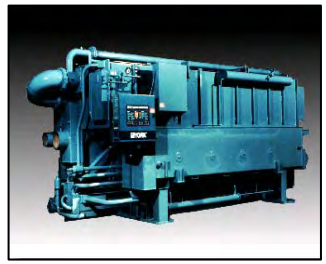
180ºF

Gas-turbine

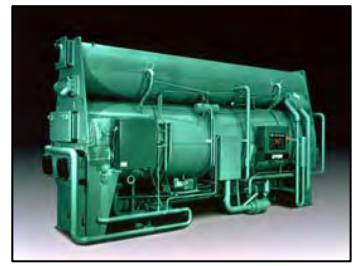
Micro-turbine

I.C. Engine

Steam Turbine Centrifugal Chiller



Double-Effect Absorption Chiller



Single-Effect Absorption Chiller

Thermally Activated Technology

Body Shop: Building Strategies

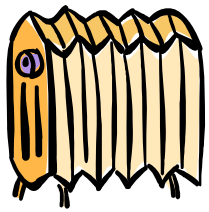
CHP Output Efficiency is generally higher for Combustion Turbine based CHP system than IC Engine based systems.

Generating Technology	Thermal Technology (Chiller)	Electrical Output (MW)	Thermal Electric Ratio (TR/kW)	CHP Output efficiency, HHV
Large Combustion Turbine	Steam Turbine	>2.5	0.6	77%
Small Combustion Turbine	Double Effect Absorption	1 to 2.5	0.7	69%
Microturbine	Double Effect Absorption	0.25 to 0.5	0.5	60%
Reciprocating Engine	Double Effect Absorption	1.5 to 5	0.2	50%
Reciprocating Engine	Single Effect Absorption	0.25 to 5	0.3	58%
Microturbine	Single Effect Absorption	0.25 to 0.5	0.4	44%

CHP Output Efficiency = (Total busbar kW + Cooling converted directly to kW) / Fuel Input (HHV)

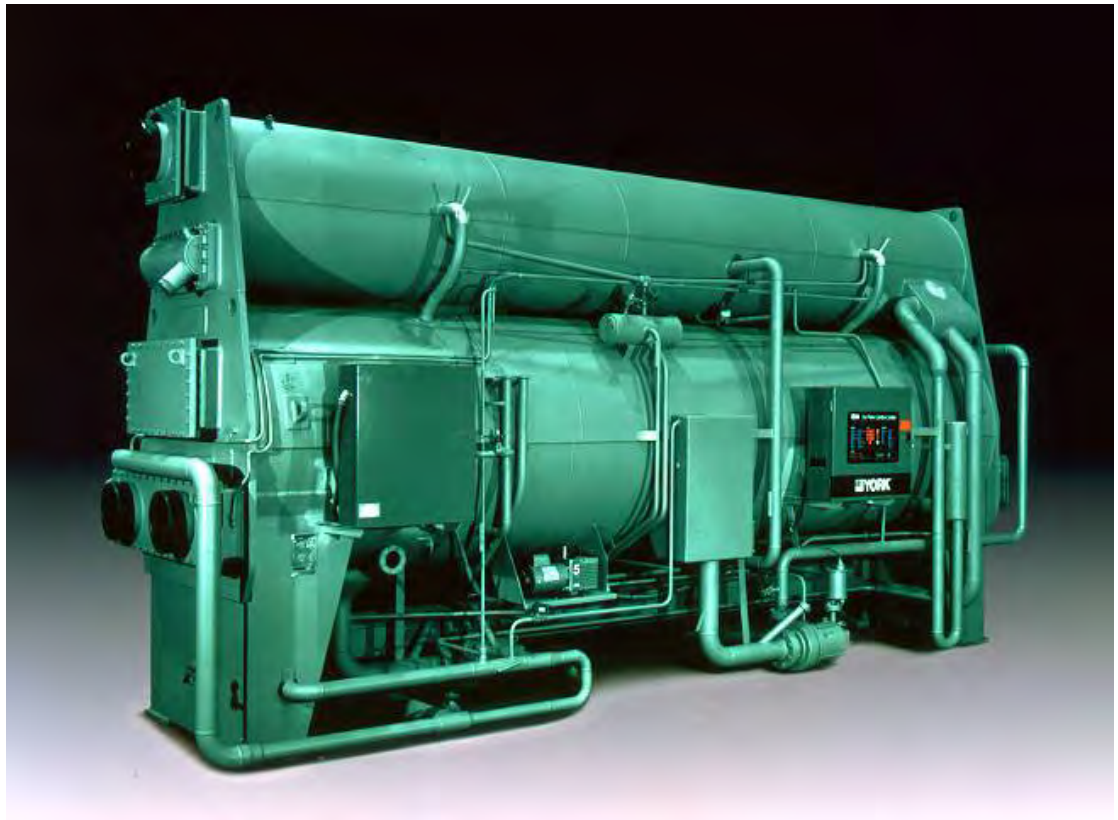
CHP <2MW

Body Shop: Building Strategies



Single Effect Absorption Chillers

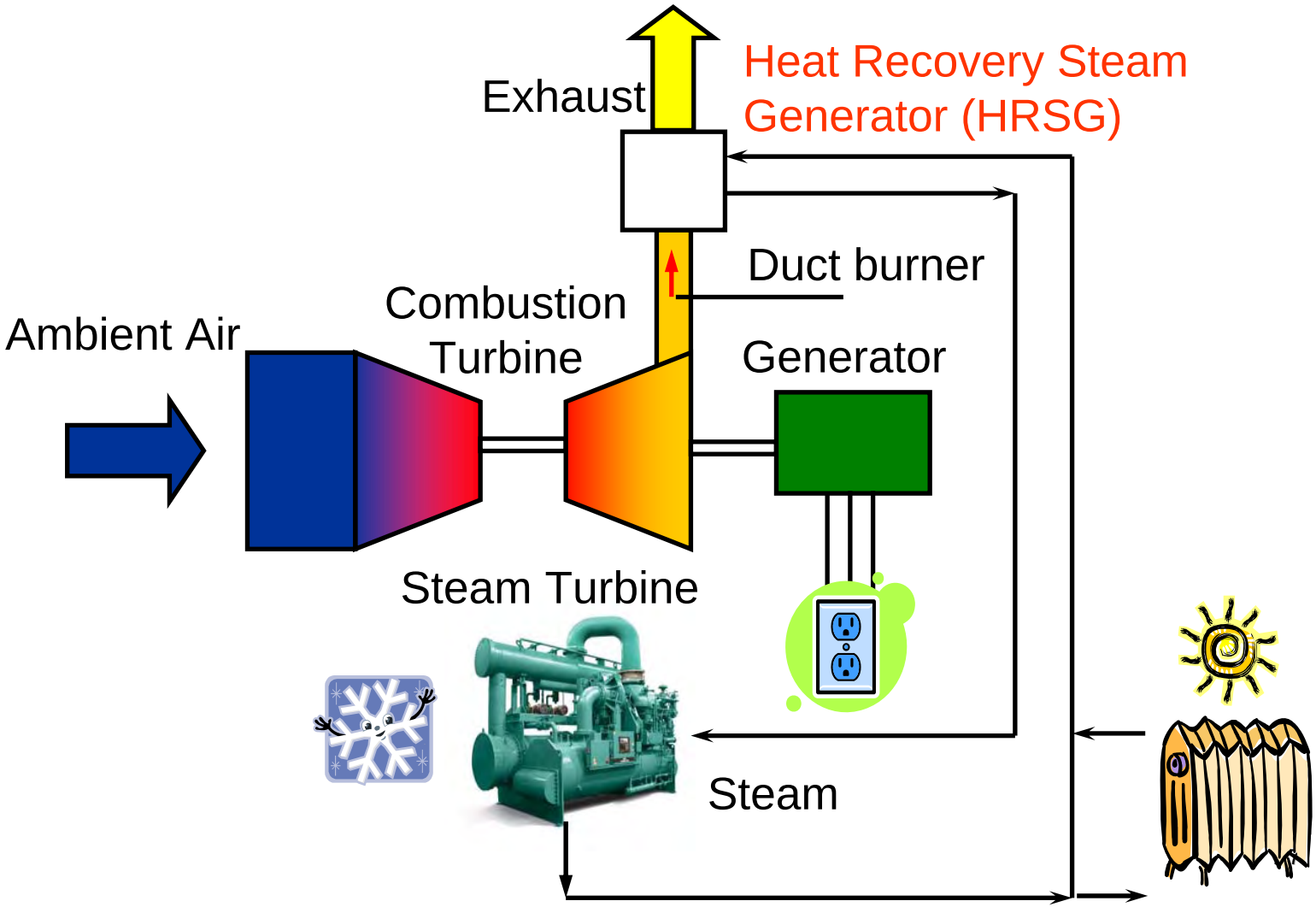
Body Shop: Building Strategies



100 to 1,300 TR, 350 to 4,500kW
Hot water & LP Steam

CHP >1 MW

Body Shop: Building Strategies



Steam Turbine Chillers

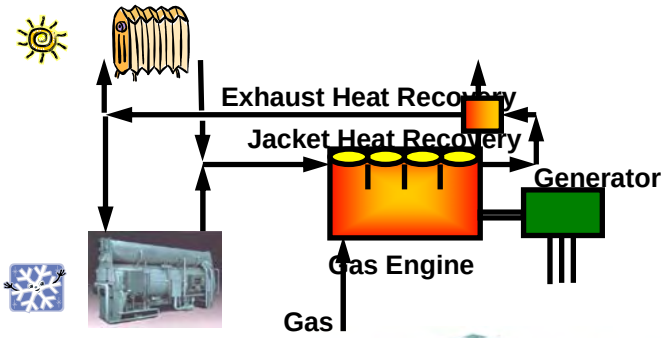
Body Shop:
Building
Strategies

700 to 5,000 TR / 2500 to 18,000 kW

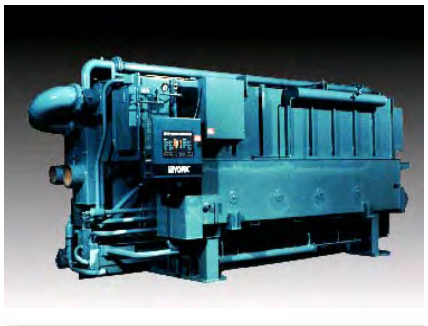
CHP Developments

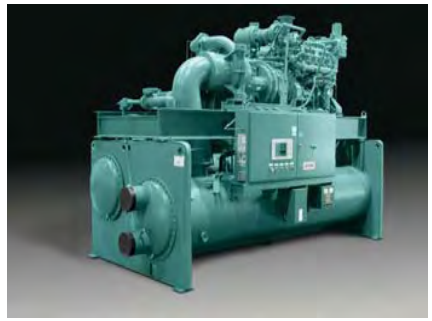
Body Shop: Building Strategies

- Traditional CHP has required complex integration
  - Generator / Heat Recovery Chillers / Controls Interconnection
  - Opportunities for failure ~ !!!
- Move to Modular Systems
  - Generator & Heat Recovery Module
    - Power side generation, integration and control
    - Heat recovery
  - Thermal Module
    - Heating – Cooling components
    - Heat rejection management
    - Distribution and Controls
- Pre-Designed Solutions Make it Easy
- **Watch this space!**



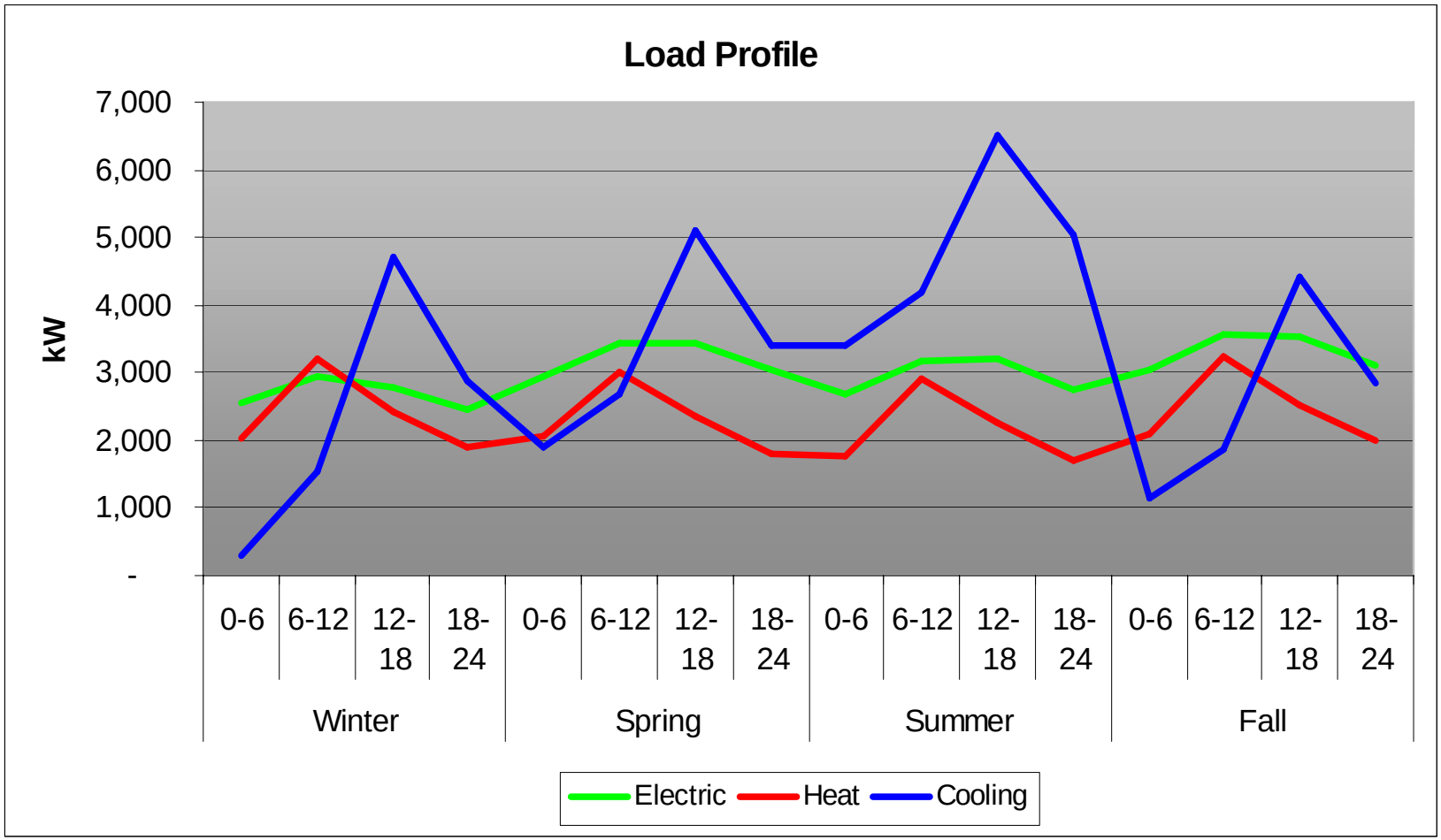
Economic & Environmental Benefits





Real World Evaluation…

Body Shop: Building Strategies



Utility Data

Body Shop: Building Strategies

Electric Rate $0.12/kW.hr
$33.3/GJ

Gas Rate $1.00/therm
$9.98/GJ

CA CO_2 Emissions 0.80lb/kW.hr
101.4kg/GJ

Gas CO_2 Emissions 11.7lb/therm
53.0kg/GJ

US CO_2 Emissions 1.3lb/kW.hr
165kg/GJ

Base Case

Body Shop: Building Strategies

- 5,000kW electric supply
- 3 x 800TR (8,400kW) electric chillers
- 17,000 MBH (5,000kW) heating boiler

Heating & Cooling

- $1,142,000 per year
- 6,100 tons / year CO_2

Power, Heating & Cooling

- $4,340,000 per year
- 16,800 tons / year CO_2

Scenario 1 – Gas Engine Drive Chillers

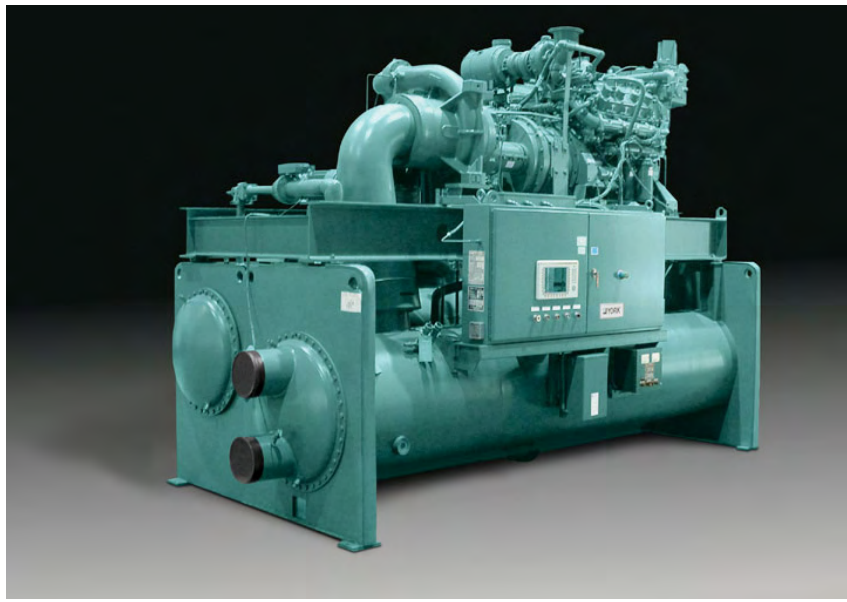
Body Shop: Building Strategies

Heating and Cooling

- 3 x 800TR gas engine chillers
- No electric chillers
- 10,000 MBH (3,000kW) heating boiler

Heating & Cooling

- $909,000 per year
- 5,300 tons / year CO_2



Capital Add - $910k
Energy Savings - $232k/yr
Maintenance - $37k/yr
Simple Payback – 4.7yrs

Scenario 2 – Heat Pump Chillers

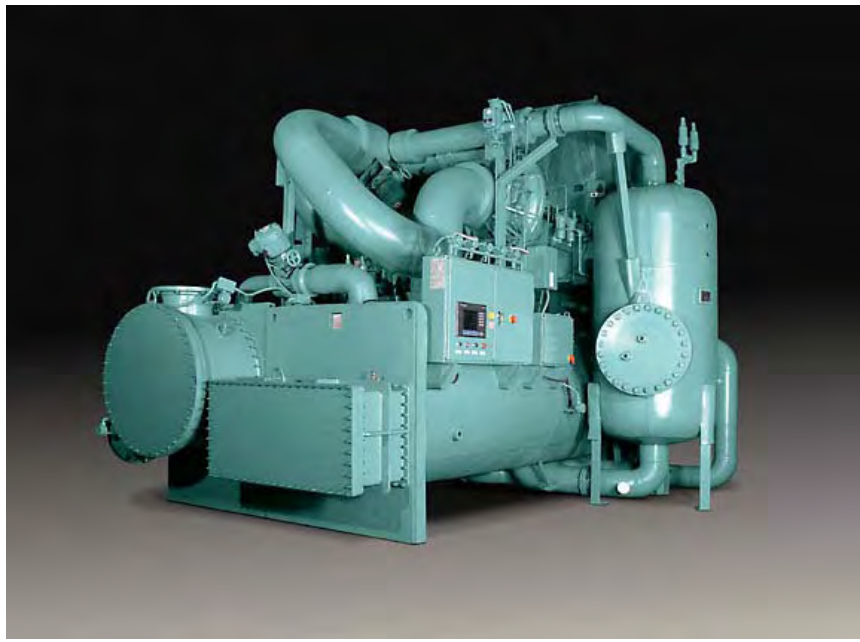
Body Shop: Building Strategies

Heating and Cooling

- 2 x 600TR heat pump chillers
- 2 x 600TR electric chillers
- 7,000 MBH (2,000kW) heating boiler

Heating & Cooling

- $839,000 per year
- 3,070 tons / year CO_2



Capital Add - $170k
Energy Savings - $303k/yr
Maintenance - $negligible
Simple Payback – 0.6yrs

Scenario 3 – Gas Engine CHP

Body Shop: Building Strategies

Electric, Heating and Cooling

- 2 x 1.2MW engine generators & heat recovery
- 1 x 600TR absorption chiller
- 2 x 900TR electric chillers
- 3,500 MBH (1,000kW) heating boiler

Power, Heating & Cooling

- $3,240,000 per year
- 7,070 tons / year CO_2

Capital Add - $1,500k
Energy Savings - $1,100k/yr
Maintenance - $173k/yr
Simple Payback – 1.6yrs

Scenario 4 – Gas Turbine CHP

Body Shop: Building Strategies

Electric, Heating and Cooling

- 1 x 1.5MW gas turbine generators & HR
- 1 x 1000TR steam turbine chillers
- 2 x 700TR electric chillers
- 3,500 MBH (1,000kW) heating boiler

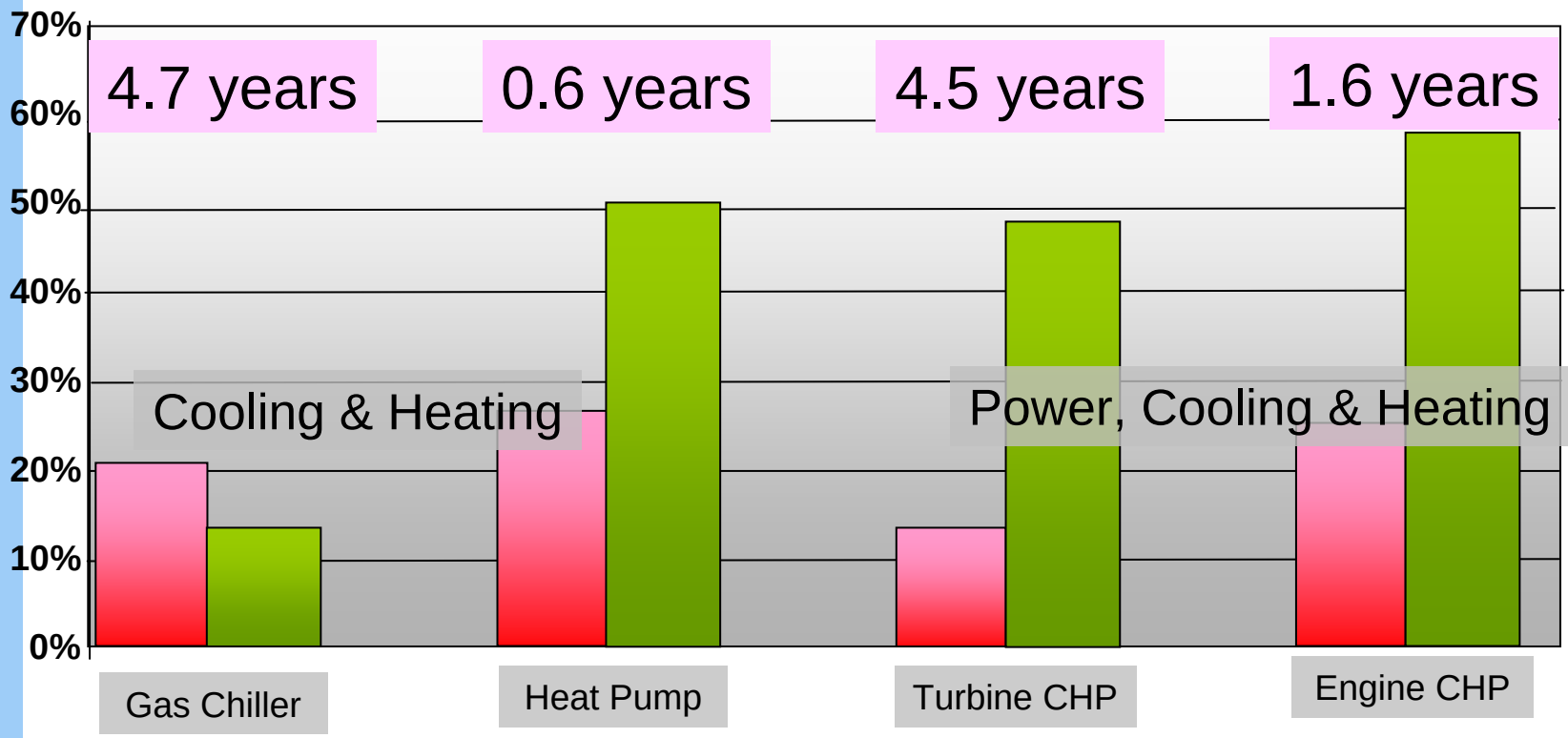
Power, Heating & Cooling

- $3,750,000 per year
- 8,770 tons / year CO_2

Capital Add - $2,200k
Energy Savings - $600k/yr
Maintenance - $104k/yr
Simple Payback – 4.5yrs

Summary

Body Shop: Building Strategies



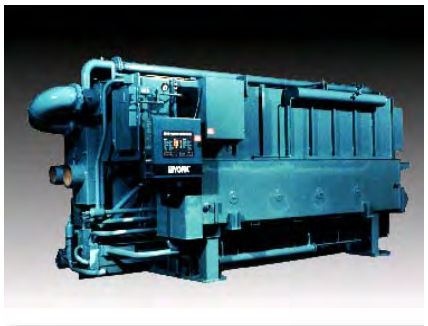
789 ton/yr | 3,040 ton/yr | 8,050 ton/yr | 9,740 ton/yr

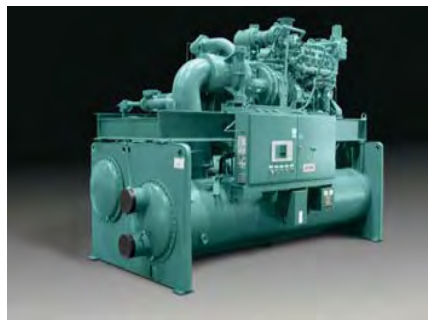
Electric $0.12/kW.h
Gas $1.0/Therm

Key: Cost Savings | CO_2 Savings

Body Shop: Building Strategies

Thank You!





Ian Spanswick – ian.spanswick@york.com